

of accumulation. The extremes of this process were, therefore, accumulation of the dust in the form of mantling loess on the borders of the "peripheral" zone, and barren stony steppes in the interior, with seas of sand-dunes following between. The dense dust-storms that during the seasons of predominant winds from the interior darken the air of northern China and southern Turkestan, are proof that the process outlined above, in the sense of Richthofen's theory, was at least one source of the loess of China and Mongolia, and his conception must stand as a beautiful and well-conceived explanation.

The writer, in reviewing the first volume of Richthofen's great work "China," in 1876, recognized the validity and strength of the argument and was led to suggest additional sources of wind-borne loess.* These were: first, the silts (chiefly glacier-ground) brought by rivers into desert regions, where after desiccation they became the prey of the winds; second, another important source would be where a region which had long been protected by heavy vegetation should, through the chemical action of infiltrating waters carrying free oxygen and organic acids, become disintegrated and decomposed, either in mass or broken up into polygonal blocks surrounded by clay detritus. Such a state exists often to depths of 100 to 300 feet in regions that have not been glaciated. When in consequence of a climatic change toward aridity such a region should lose its protecting vegetation, it would offer to the action of the winds an immense store of loosely aggregated material ready for easy and rapid removal. On the other hand, in the oncoming of a glacial epoch, such a condition would explain the origin of the greater part of the glacial till and large and small boulders transported in the slow movement of the great ice-cap. This modification was accepted by Richthofen and reproduced in the second volume of "China."

The expedition of 1903 offered opportunities for studying the loess of Turkestan and observing the way in which it was formed, and certain facts were noted that explain some points that have been considered by many to be inconsistent with Richthofen's theory. These observations showed clearly that all loess is primarily brought by wind and arrested by grasses under the protection of continued generations of which it slowly accumulates. But there are two sources from which the wind derives the dust. One is from the bare surface of deeply disintegrated mountains, as on the Pamirs, and the uninterrupted deflation by the winds of the rocks of the desert, which are perpetually disintegrating under the influence of the great daily changes of temperature. The other is from the flood-plains and dry deltas of rivers and from the shores of retreating lakes, as I had suggested in the paper referred to. This brings in water as an intermediate factor in transportation, in connection with the origin of loess in certain regions. In every case, however, the process must be in an arid or more than semi-arid climate, where extensive rock areas or widespreading flood-plains are in a state of desiccation. On the Pamirs we found the mountains buried in the unmoved products of their own disintegration. In this worst of desert regions, rocks at the surface crumble

*The Relation of Secular Rock Disintegration to Loess, Rock Basins, and Glacial Deposits. American Journal of Science, February, 1879.